Fabrication of ternary composite $ZnFe_2O_4/Co_3O_4/G$ for high performance supercapacitor

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Mamraj Singh

Department of Physics, University of Rajasthan, Jaipur, 302004, India

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Rajan Lakra, Rajiv Kumar, Nagsen Meshram, Mam

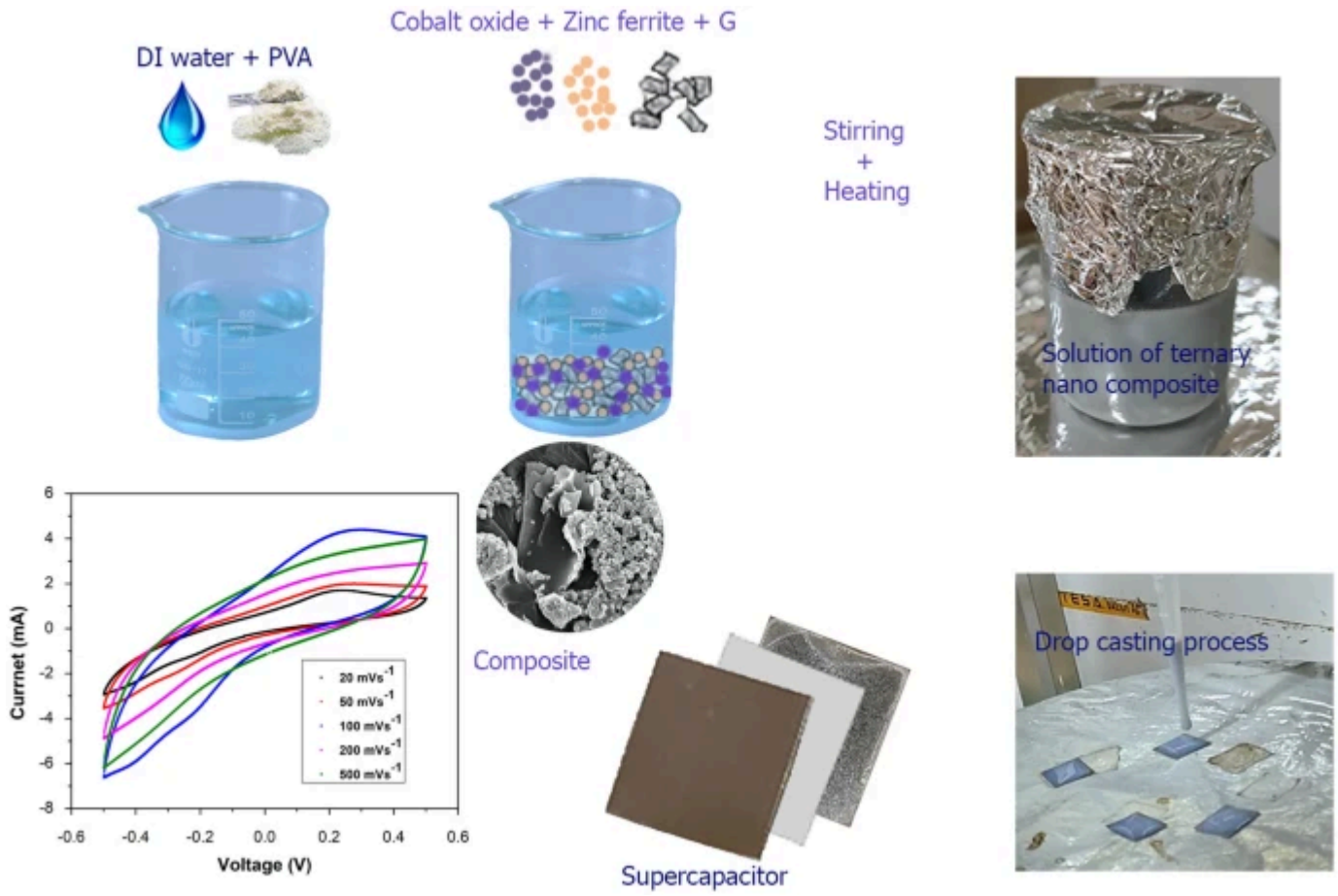
Dhirendranath Thatoi & Ankur Soam

Abstract

The present work includes fabrication of a ternary composite of $ZnFe_2O_4$, Co_3O_4 and graphene ($ZnFe_2O_4/Co_3O_4/G$) for high performance supercapacitor. $ZnFe_2O_4$, Co_3O_4 and graphene are combined in a single electrode in order to have large value of specific capacitance with excellent cycle stability. The electrochemical properties were evaluated using cyclic voltammetry, constant current charging/discharging and electrochemical impedance spectroscopy. The supercapacitor with two electrodes of $ZnFe_2O_4/Co_3O_4/G$ exhibited a specific capacitance of 580 Fg^{-1} at scan rate 20 mVs^{-1}, which is larger than $ZnFe_2O_4/G$ and Co_3O_4/G based binary composites. XRD results confirm the formation of ternary composite. SEM and TEM analysis have been performed for morphology

investigation. $ZnFe_2O_4$ and Co_3O_4 nanoparticles were observed to be attached well on the graphene nanosheet. The synthesized electrode performed favourable and satisfactory performance in supercapacitor.

Graphical Abstract



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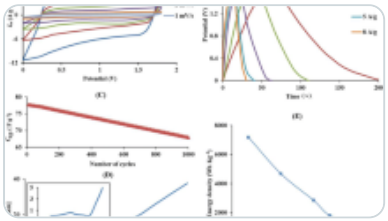

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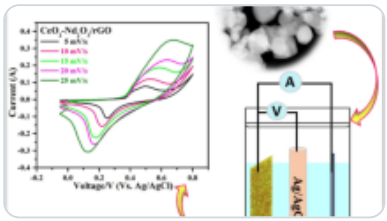

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Data availability

The datasets generated during the current study are available from the corresponding author on reasonable request.

References

1. H.-C. Li, H.-R. Shen, Y. Shi, L. Wen, F. Li, Progress and prospects of graphene for in-plane micro-supercapacitors. New Carbon Mater. **37**(5), 781–801 (2022)

Article CAS Google Scholar

2. Golam Masud Karim, Pronoy Dutta, Abhisek Majumdar, Amalika Patra, Sujit Kumar Deb, Snehasish Das, Neha V. Dambhare, Arup K. Rath, Uday Narayan Maiti, Ultra-fast electro-reduction and activation of graphene for high energy density wearable supercapacitor asymmetrically designed with MXene. Carbon **203**, 191–201 (2023)

Article CAS Google Scholar

3. D. Liu, H. Wang, Du. Pengcheng, W. Wei, Qi. Wang, P. Liu, Flexible and robust reduced graphene oxide/carbon nanoparticles/polyaniline (RGO/CNs/PANI) composite films: excellent candidates as free-standing electrodes for high-performance supercapacitors. Electrochim. Acta **259**, 161–169 (2018)

Article CAS Google Scholar

4. Y. Chen, Z. Liu, L. Sun, Z. Lu, K. Zhuo, Nitrogen and sulfur co-doped porous graphene aerogel as an efficient electrode material for high performance supercapacitor in ionic liquid electrolyte. J. Power Sources **390**(215), 223 (2018)

Google Scholar

5. Ankur Soam, Application of ferrites as electrodes for supercapacitor. Ferrites: Synth Appl **55**, 99381 (2021)

Google Scholar

6. Shuhua Yang, Zhenzhen Han, Fangyuan Zheng, Jing Sun, Xiaopeng Yang ZhensongQiao, Li. Li, Cuncheng Li, Xuefeng Song, Bingqiang Cao, ZnFe2O4 nanoparticles-cotton derived hierarchical porous active carbon fibers for high rate-capability supercapacitor electrodes. Carbon **134**, 15–21 (2018)

Article CAS Google Scholar

7. F.M. Ismail, M. Ramadan, A.M. Abdellah, I. Ismail, N.K. Allam, Mesoporous spinel manganese ZnFe2O4 for high-performance supercapacitors. J. Electroanal. Chem. **817**, 111–117 (2018)

Article CAS Google Scholar

8. A.K. Ghasemi, M. Ghorbani, M.S. Lashkenari, N. Nasiri, Controllable synthesis of ZnFe2O4 nanostructure with tunable morphology on polyaniline nanocomposite for supercapacitor application. J. Energy Storage **51**, 104579 (2022)

Article Google Scholar

9. Abhijeet V. Shinde, Swati J. Patil, Seung-Kyu. Hwang, GanjiSeeta Rama. Raju, Yun-Suk. Huh, Young-Kyu. Han, Nilesh R. Chodankar, Surface modified ZnFe2O4 as a carbon-alternative negative electrode for high-energy hybrid supercapacitor. Ceram. Int. **47**(11), 16333–16341 (2021)

Article CAS Google Scholar

10. M.B. Poudel, H.J. Kim, Synthesis of high-performance nickel hydroxide nanosheets/gadolinium doped-α-MnO2 composite nanorods as cathode and Fe3O4/GO nanospheres as anode for an all-solid-state asymmetric supercapacitor. J. Energy Chem. **64**, 475–484 (2022)

Article CAS Google Scholar

11. W. Jinxi, W. Aimin, A.K. Ghasemi, M.S. Lashkenari, E. Pashai, C. Karaman, D.E. Niculina, Karimi-Maleh H Tailoring of ZnFe2O4-ZrO2-based nanoarchitectures catalyst for supercapacitor electrode material and methanol oxidation reaction. Fuel **334**, 126685 (2023)

Article Google Scholar

12. A. Thadathil, Y.A. Ismail, P. Periyat, Ternary 3D reduced graphene oxide/Ni 0.5 Zn 0.5 Fe 2 O 4/polyindole nanocomposite for supercapacitor electrode application. RSC

Adv. **11**(57), 35828–35841 (2021)

Article CAS Google Scholar

13. N.H. Azman, M.S. Mamat@ Mat Nazir, L.H. Ngee, Y. Sulaiman, Graphene-based ternary composites for supercapacitors. Int. J. Energy Res. 42(6), 2104–2116 (2018)

14. Maedeh Mousavi Nakhodchari, Majid Seifi, Mohammad Taghi Tourchi. Moghadam, Ternary MnCo2O4/MWCNT/rGO nanocomposites as high-performance supercapacitor electrode materials. J. Phys. Chem. Solids **174**, 111170 (2023)

Article Google Scholar

15. M.B. Poudel, H.J. Kim, Confinement of Zn-Mg-Al-layered double hydroxide and α-Fe2O3 nanorods on hollow porous carbon nanofibers: a free-standing electrode for solid-state symmetric supercapacitors. Chem. Eng. J. **429**, 132345 (2022)

Article CAS Google Scholar

16. Milan Babu Poudel, Allison A. Kim, Prakash Chandra Lohani, Dong Jin Yoo, Han Joo Kim, Assembling zinc cobalt hydroxide/ternary sulfides heterostructure and iron oxide nanorods on three-dimensional hollow porous carbon nanofiber as high energy density hybrid supercapacitor. J. Energy Storage **60**, 106713 (2023)

Article Google Scholar

17. Rajan Lakra, Rahul Kumar, Dhirendra Nath Thatoi, Prasanta Kumar Sahoo, Ankur Soam, Synthesis and characterization of Co3O4 (Co3O4) nanoparticles. Mater.Today: Proc. **41**, 269–271 (2021)

CAS Google Scholar

18. Rajan Lakra, Rahul Kumar, Prasanta Kumar Sahoo, Deepanshu Sharma, D. Thatoi, D. Thatoi, A. Soam, Facile synthesis of Co3O4 and graphene nanosheets nanocomposite

for aqueous supercapacitor application. Carbon Trends **7**, 100144 (2022)

Article CAS Google Scholar

19. A. Soam, R. Kumar, C. Mahender, M. Singh, D. Thatoi, R.O. Dusane, Development of paper-based flexible supercapacitor: bismuth ferritegraphene nanocomposite as an active electrode material. J. Alloys Compd. **813**, 152145 (2020)

Article CAS Google Scholar

20. R. Lakra, R. Kumar, D. Thatoi, A. Soam, Synthesis of TiO2 nanoparticles as electrodes for supercapacitor. Mater. Today: Proc. **1**(74), 863–6 (2023)

Google Scholar

21. S.S. Kumbhar, M.A. Mahadik, V.S. Mohite, K.Y. Rajpure, J.H. Kim, A.V. Moholkar, C.H. Bhosale, Structural, dielectric and magnetic properties of Ni substituted ZnFe2O4. J. Magn. Magn. Mater. **363**, 114–120 (2014)

Article CAS Google Scholar

22. H. Jiang, T. Zhao, C. Li, J. Ma, Hierarchical self-assembly of ultrathin nickel hydroxide nanoflakes for high-performance supercapacitors. J. Mater. Chem. **21**(11), 3818–3823 (2011)

Article CAS Google Scholar

23. Bhamini Bhujun, Michelle TT. Tan, Anandan S. Shanmugam, Study of mixed ternary transition metal ferrites as potential electrodes for supercapacitor applications. Results Phys. **7**, 345–353 (2017)

Article Google Scholar

24. Ayan Sarkar, Ashutosh K. Singh, Debasish Sarkar, Gobinda Gopal Khan, Kalyan Mandal, Three-dimensional nanoarchitecture of BiFeO3 anchored TiO2 nanotube

arrays for electrochemical energy storage and solar energy conversion. ACS Sustain. Chem. Eng. **3**(9), 2254–2263 (2015)

Article CAS Google Scholar

25. C.D. Lokhande, T.P. Gujar, V.R. Shinde, Rajaram S. Mane, Sung-Hwan. Han, Electrochemical supercapacitor application of pervoskite thin films. Electrochem. Commun. **9**(7), 1805–1809 (2007)

Article CAS Google Scholar

26. V.V. Jadhav, M.K. Zate, S. Liu, M. Naushad, R.S. Mane, K.N. Hui, S.H. Han, Mixed-phase bismuth ferrite nanoflake electrodes for supercapacitor application. Appl. Nanosci. **6**(4), 511–519 (2016)

Article CAS Google Scholar

27. M.B. Poudel, M. Shin, H.J. Kim, Polyaniline-silver-manganese dioxide nanorod ternary composite for asymmetric supercapacitor with remarkable electrochemical performance. Int. J. Hydrog. Energy **46**, 474–485 (2021)

Article CAS Google Scholar

28. Milan Babu Poudel, A. Rhan Kim, Shanmugam Ramakrishan, Natarajan Logeshwaran, Santosh Kumar Ramasamy, Han Joo Kim, Dong Jin Yoo, Integrating the essence of metal organic framework-derived ZnCoTe–N–C/MoS2 cathode and ZnCo-NPS-N-CNT as anode for high-energy density hybrid supercapacitors. Compos. Part B: Eng. **247**, 110339 (2022)

Article CAS Google Scholar

29. M.B. Poudel, P.C. Lohani, A.A. Kim, Synthesis of silver nanoparticles decorated tungsten oxide nanorods as high-performance supercapacitor electrode. Chem. Phys. Lett. **804**, 139884 (2022)

Article Google Scholar

30. Rajendra Kumar Nare, Sivalingam Ramesh, Praveen Kumar Basavi, Vijay Kakani, Hemraj M. ChinnaBathula, Prakash Babu Yadav, Rama Krishna Dhanapal, Reddy Kotanka, Visweswara Rao Pasupuleti, Sonication-supported synthesis of Co3O4 assembled on an N-MWCNT composite for electrochemical supercapacitors via three-electrode configuration. Sci Rep **12**(1), 1–10 (2022)

Article Google Scholar

31. Z. Zhao, H. Wang, H. Huang, L. Li, Yu. Xianghua, Graphene oxide/polypyrrole/polyaniline composite hydrogel synthesized by vapor-liquid interfacial method for supercapacitors. Colloids Surf. A **626**, 127125 (2021)

Article CAS Google Scholar

32. A. Soam, R. Kumar, P.K. Sahoo, C. Mahender, B. Kumar, N. Arya, M. Singh, S. Parida, Dusane RO Synthesis of nickel ferrite nanoparticles supported on graphene nanosheets as composite electrodes for high performance supercapacitor. ChemistrySelect **4**(34), 9952–9958 (2019)

Article CAS Google Scholar

33. Saira Ishaq, Mahmoud Moussa, Farah Kanwal, Muhammad Ehsan, Muhammad Saleem, Truc Ngo Van, DusanLosic, Facile synthesis of ternary graphene nanocomposites with doped metal oxide and conductive polymers as electrode materials for high performance supercapacitors. Sci. Rep. **9**(1), 1–11 (2019)

Article CAS Google Scholar

34. C. Rajan Lakra, Balwant Kr Mahender, Rahul Kumar Singh, Sandeep Kumar, Prasanta Kumar Sahoo, Dhirendranath Thatoi, Ankur Soam, $ZnFe_2O4$ nanoparticles supported on graphene nanosheets for high performance supercapacitor. J. Electron. Mater. **52**, 2676–2684 (2023)

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Author information

Authors and Affiliations

Department of Mechanical Engineering, Siksha 'O' Anusandhan, Deemed to be University, Bhubaneswar, India
Rajan Lakra, Dhirendranath Thatoi & Ankur Soam

Department of Physics, University of Rajasthan, Jaipur, 302004, India
Rajiv Kumar, Mamraj Singh, Deepika Choudhary & Neha Jain

Institute of Chemical Technology Marathwada Campus, Jalna, Maharashtra, 431203, India
Nagsen Meshram

Corresponding author

Correspondence to Ankur Soam.

Ethics declarations

Conflict of interests

The authors have no conflicts of interest to declare. All authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

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Supplementary Information

Below is the link to the electronic supplementary material.

Supplementary file1 (DOCX 3641 KB)

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